Pestic. Sci. 1998, **52**, 388–393

Consumer Acceptance of Transgenic Crops‡

Lynn J. Frewer,* Chaya Howard & Jackie I. Aaron

Institute of Food Research, Earley Gate, Reading, Berks RG6 6BZ, UK

14 March 1997; revised version received 9 September 1997; accepted 8 December 1997)

Abstract: It has long been recognised that a key determinant of the future development of genetic engineering in food production is likely to be consumer acceptance. Much of the earlier research into acceptance issues has assumed that public perceptions of genetic engineering are defined by beliefs about the technology overall. However, it is now known that acceptance of novel products is unlikely to be related to general attitudes towards genetic engineering. People's perceptions of risk and benefit associated with particular products and applications will determine acceptance. There is a need to develop effective risk–benefit communication strategies, based on the best scientific information available, in order to enable the public to make informed choices about consuming the products of genetic engineering. It is also essential to develop effective communication methods if the public is to contribute to the wider debate about strategic development of genetic engineering. Issues of social context (such as trust in risk regulators) must also be considered. Providing information is likely to change people's attitudes, which will in turn generate further public concerns and create a demand for more information about genetic engineering. © 1998 SCI

Pestic. Sci., **52**, 388–393 (1998)

Key words: consumer attitudes; genetic modification; agriculture

1 INTRODUCTION

Public resistance to emerging technologies has long been recognised as important in development and application of these technologies.[1] Indeed, parallels have been made between public reactions to nuclear technology and to genetic engineering.[2] Resistance to new technologies has been described as 'a protest against the feeling of being overwhelmed by innovation processes'.[3] Whilst historically the consumer acceptance debate has focused on the need for the general public to be educated about genetic engineering in order to ensure its future success, the focus of the current debate regarding public perception issues has shifted. Current emphasis is on the creation of an informed public able to make decisions regarding consumption of products resulting from genetic engineering, and who can provide a constructive input to the strategic development of future applications.[4]

No technology can be isolated from the social context in which it is embedded,[5] and this wider social environment must be taken into account in any communication designed to inform the public about genetic engineering and food production. Salient questions must address issues associated with the introduction of products into the marketplace, as well as the formation of more general attitudes towards genetic engineering. Emerging technologies reach the attention of planners, forecasters, and policy makers in a time sequence, such that policy regarding public responses is not put in place during scientific development.[6] Nuclear power has been the focus of negative public reaction since the 1950s, and public attitudes are unlikely to change, as they are very well formed. Public opinion about genetic modification is only just beginning to crystallize—the direction that this opinion takes is likely to determine the future direction of policy surrounding genetic engineering, and the path of future developments.

‡ Based on a paper presented at the meeting 'Transgenic Crops: New Perspectives in Crop Protection', organised by L. G. Copping on behalf of the Physicochemical and Biophysical Panel of the SCI Pesticides Group and held at 14–15 Belgrave Square, London on 11 March 1997.

* To whom correspondence should be addressed.

Contract/grant sponsor: Biotechnology and Biological Sciences Research Council.

 Pestic. Sci. 0031-613X/98/$17.50. Printed in Great Britain

2 PREVIOUS RESEARCH

2.1 Specificity of public attitudes

Perceptions which define attitudes are more likely to be defined by specific applications, rather than considerations intrinsic to genetic engineering *per se*.[7–10] However, it is also important to ask appropriate questions in order to predict what is likely to be a focus of public objection. In order to understand what these characteristics and perceptions actually are, it is essential that qualitative methodology be applied in order to elicit actual and realistic concerns, rather than to use researcher-generated rating scales to assess the psychological factors associated with resistance to a particular technology. One method employed to address this problem is to use semi-structured interviewing in conjunction with analytical techniques such as generalised Procrustes analysis.[11] The aim is to determine what are the real concerns of the public regarding different food-related risks.

In two separate experiments, the underlying concerns respondents expressed regarding different applications of genetic engineering drawn from food-related, agricultural and medical areas were elicited. In the first study, 15 applications of genetic engineering were presented in very general terms, such as 'genetic engineering of plants for food production purposes (plants/food). In the second study, a different group of people was asked to respond to 15 more specific applications such as 'herbicide-resistant crops', where the tangible benefits of the technology were made more explicit. Twenty-five different respondents were included in each group. Both sets of data were submitted to generalised Procrustes analysis, and graphical representations of concern about applications generated. From this, the combined results of both studies were used to design two survey instruments, one focusing on the general applications of the technology, and one on specific applications as already described. Each survey was sent to 200 respondents. The application of principal components analysis indicated that respondents saw applications of genetic engineering which were presented in general terms as either positive (necessary, beneficial or advantageous) or negative (risky, unethical, harmful or unnatural) (Fig. 1).

There is a clear distinction in attitude between applications involving plants and micro-organisms, which are associated with positive attitudes, and those involving animals and human DNA, which are associated with negative attitudes. This effect is independent of whether the application is related to food, medicine or agriculture.

The specific applications tended to be more highly differentiated in perceptual terms. Negative perceptions linked to some applications (such as mice genetically modified to develop cancer for medical research) were

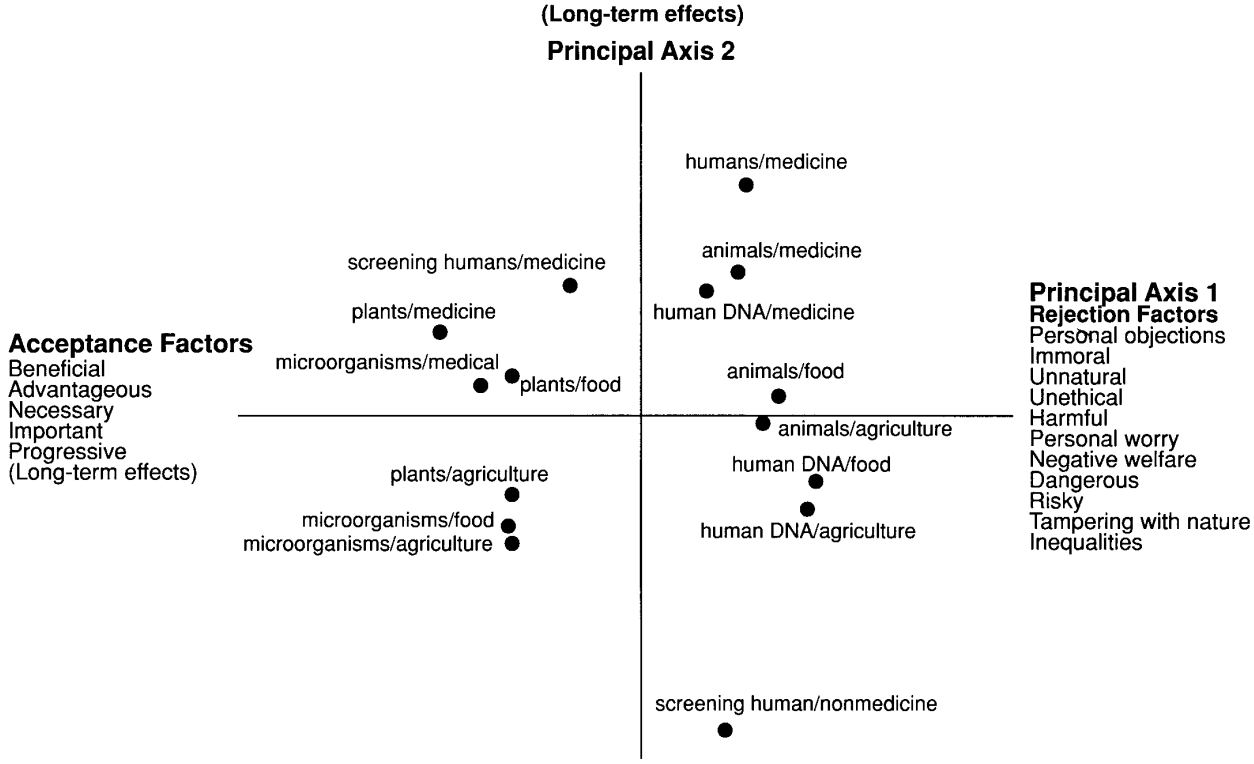

Fig. 1. Location of general applications of genetic engineering within two-component space. Principal Axis 1 indicates the first component which accounted for 88% of the variance. Factors identified as positive (Acceptance Factors) are listed in order of importance on the left, and similarly those as negative (Rejection Factors) on the right. Principal Axis 2 indicates the second component (9% of the variance) and is 'Long Term Effects'. Variables that load on more than one axis are in parentheses.

mediated by perceptions of need or benefit. Some applications (e.g. genetically modified yeasts for brewing) were seen as low in risk, but also unnecessary (Fig. 2).

The distinction between applications involving plants and micro-organisms and those involving animals and human genetic material is still apparent for applications of genetic engineering where more information is provided about the different applications (the additional information is not shown in detail here). However, exposure to the tangible benefits of each application results in negative attitudes towards some applications being mediated by perceptions of need or benefit, particularly if those applications are related to medicine. Full details of this analysis are given in Reference 8.

Replication of this research using an Italian sample produced an almost identical pattern of rejection or acceptance for the different applications—although, in the Italian sample, concerns did not focus on risk. Instead, respondents expressed concern about the ethical issues associated with the different applications of the technology. This effect was attributed to the lower level of media coverage of genetic engineering in Italy relative to the UK. The results indicate that public concerns are not simply driven by perceptions of risk. Failure to ask appropriate questions may result in erroneous predictions about public acceptance of genetic engineering. For example, it is known that British and Italian respondents have a similar pattern of objection to applications involving human DNA or animals. In the British sample, objections were more focused by combined perceptions of risk and ethical concern. The Italians, however, make similar decisions regarding acceptance and rejection of different applications on the basis of ethical considerations alone. It is thought that this effective was the result of less pubic knowledge and reduced media coverage of genetic engineering in the Italian sample.[12] It should be noted, however, that it is difficult to dissociate ethical issues from those of perceived risk and benefit, particularly given the complexity of ethical issues surrounding genetic engineering.[13]

2.2 Individual differences in attitudes

There is evidence that individual differences in attitudes towards genetic engineering exist, and that these differences are defined by co-existing attitudes (for example, environmental concern) as well as demographic factors. For example, 200 respondents were presented with different applications of genetic engineering shown in very

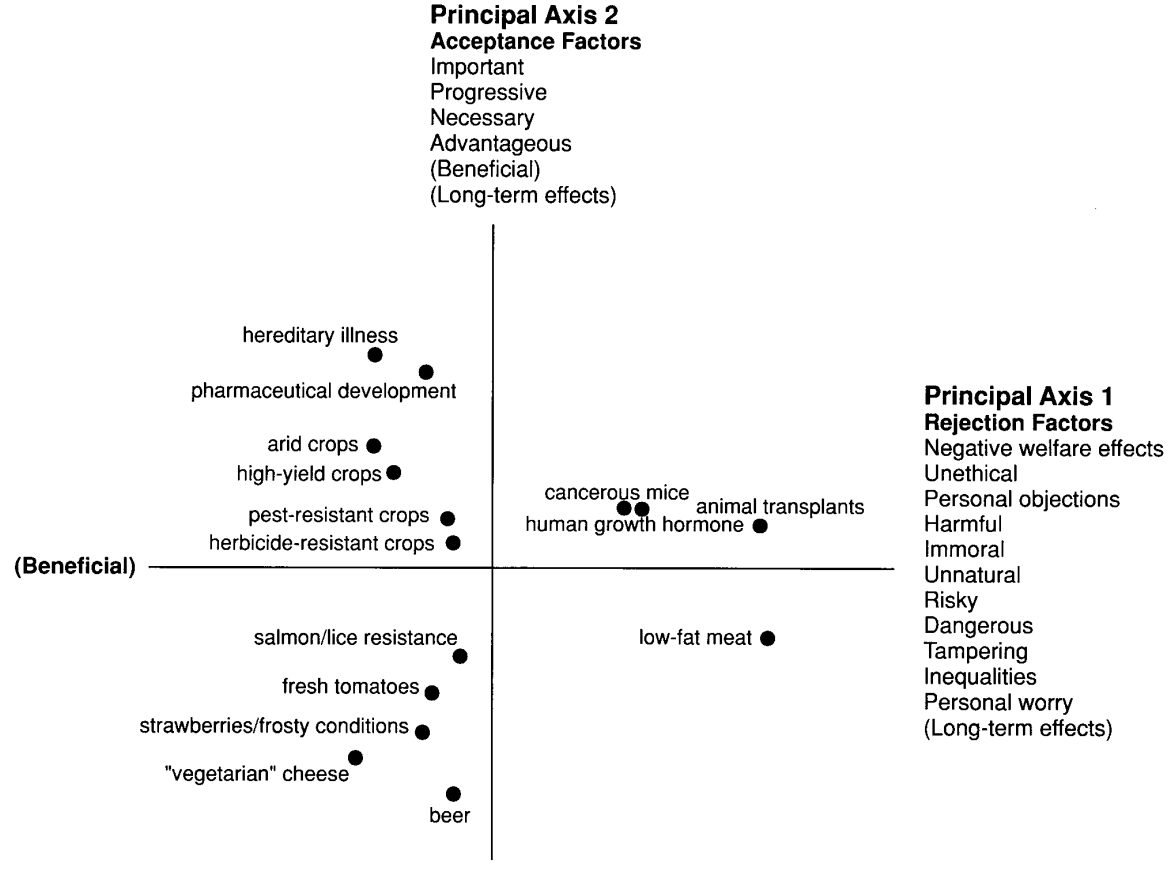

Fig. 2. Location of specific applications of genetic engineering within two-component space. Principal Axis 1 indicates the first component associated with Rejection Factors which accounted for 71% of the variance. Principal Axis 2 indicates the second component associated with Positive Acceptance Factors (27% of the variance) and is scored more highly at the top. Variables that load on more than one axis are in parenthesis.

general terms, where the tangible benefits of genetic engineering were not obvious. These applications were identical to those in the previous analysis. The application of 'objection mapping' techniques[14] (which permit the identification of respondents who exhibit systematic patterns in self-report attitude data) indicated that most respondents objected less to applications involving plants and micro-organisms than to those involving animals or human genetic material. Individual differences in objection focused on applications involving animals or human genetic material, with women and those who are very concerned about the environment having the greatest objections. This would indicate that those individuals who consider themselves 'green' are more likely to oppose these applications if they have little or no information about why genetic engineering is being applied. Similar data were collected about the 15 specific applications used above where the tangible benefits were more obvious to respondents. Individual differences tended to reduce when specific applications were used as stimuli, although the focus of concern was still on applications involving animals and human genetic material. However, gender differences between the respondents were not statistically significant, and those who had high levels of environmental concern were, in this instance, differentiated by increased objection to large-scale agricultural applications.[15] These results suggest that communication is most likely to be effective if concrete and tangible information is provided about specific application. Most opposition to large-scale agricultural applications is likely to be from those individuals with high levels of self-reported environmental concern. Presumably evidence of environmental advantage would facilitate acceptance in this group.

2.3 Process versus product

Even for non-controversial applications of genetic engineering, process considerations (that is, production through the use of genetic engineering as opposed to some other method) appear to be important, even if the final product does not contain genetically modified DNA. Perceptions of consumer benefit are likely to have greatest impact on consumer decision-making if the application is also perceived to be low in risk. Consumer attitudes towards genetic engineering (defined for respondents as transfers of genetic material between species), protein engineering (altering the characteristics of an organism without transferring genetic material from another species), and traditional selective breeding of micro-organisms were compared. All these technologies were applied to the manufacture of novel cheeses with different benefits, which were directed towards the health of the consumer, product quality, the environment, animal welfare or the benefit of the manufacturer. Conjoint analysis indicated that 79% of the sample made decisions based on process considerations, although tangible benefit was a more important factor in their decisions. A further 19% did not consider the process important, but tended to make decisions based on consumer benefits alone. Negative perceptions associated with genetic engineering may be offset by consumer understanding of the tangible benefits of genetic engineering, providing these are for the consumer and not the manufacturer.[16]

2.4 Social context and risk communication

Risk perception is socially constructed, and individual behaviours are driven by perceptions or beliefs about risks rather than technical risk estimates provided by experts.[16,17] It is important to examine the wider social context in which different hazards, and risk information, are embedded. For example, trust, both in those responsible for regulating the risks, and those supplying information about the hazard, is likely to have a significant impact on perceptions.[18] In the UK, distrusted sources include the government and industry. This is in part because there is a public perception that these sources are not proactive in the provision of information, or hide information from the public in order to maintain a vested interest or promote a particular view.[19] When taken with the general decline in the credibility of science and scientists, the issue of trust becomes even more important. The inclusion of all interested parties in the decision process surrounding risk issues may help improve the credibility of distrusted sources. For example, including representatives of consumer groups and environmental organisations in discussions surrounding regulation will ensure that the opinions of divergent groups are represented.

Much of the opposition to Monsanto's genetically modified soya was associated with the lack of labelling (particularly as the novel product was not segregated from the traditional material). Labelling novel genetically modified products has two advantages. Firstly, the consumer has a choice about the product. This is likely to provide additional information about why genetic engineering is being applied. The concrete benefits of application become more obvious when the product is made available. Secondly, labelling is likely to signal to the public that genetic engineering is not being 'hidden' by manufacturers, and being forced on an unsuspecting public. The prominent labelling of the Zeneca genetically modified tomato paste resulted in a marketing success, and almost no expression of public concern.

Labelling is likely to increase perceptions of personal control over consumption of genetically modified products. It is important to ensure that products are labelled and that these labels are understood by the public, an approach supported by both consumer groups and the supermarkets. Pragmatic problems in

labelling products with many different ingredients, some of which may be genetically engineered, have indicated that more general information distributed within a shopping environment might be appropriate.

Finally, public attitudes are likely to become focused as the products of genetic engineering become available. It is essential that questions surrounding the public understanding of genetic engineering be addressed early in the process of product development.

3 PUBLIC UNDERSTANDING OF SCIENCE

Rabino[20] has noted that, in Germany, public acceptance of genetic engineering is low—an effect scientists attribute to one-sided media coverage, sensitivity to historical events of the 20th century (such as the Eugenics movement) and powerful activist opposition. Rabino notes that there is a need for German scientists working in genetic engineering to make a long-term commitment to communication about all aspects of genetic engineering. Such an approach has improved public confidence in Denmark, although this has been less successful in the Netherlands.[4] Improved understanding may indeed polarise attitudes,[21] such that people who are very negative about genetic engineering select that information with which they agree, which reinforces their view, and *vice versa*. Other psychological factors such as individual preference for risk ignorance or active avoidance of scientific information[22] may also act as barriers to public understanding of genetic engineering, and there is a need to investigate these effects further.

4 FUTURE RESEARCH

It is essential that effective intervention studies for public understanding of genetic engineering be developed, and the impact of public understanding of science on attitudes and acceptance issues systematically identified. These issues become particularly salient within the context of specific product examples. Current research is focusing on the predictive capacity of general attitudinal models in combination with the theory of reasoned action[23] in order to examine the relationship between attitudes and consumer decision-making with respect to particular consumer products.[24] The long-term effects of information intervention also need to be assessed, as effects may dilute over time.

5 CONCLUSIONS

Consumer perceptions of the risks and benefits associated with all applications of genetic engineering are continuously evolving, and at present appear to be driven by attitudes linked with specific applications of genetic engineering. The importance of crisis communication, and the effects of information transmission in a crisis context, needs to be understood. For example, if the public perceive that there is an inappropriate application of genetic engineering, or if an error is made which signals a high risk potential associated with genetic engineering, then attitudes may become very negative to genetic engineering overall. The negative impact of a hazardous event occurring may influence general attitudes as well as responses to specific products. Effective risk–benefit communication and transparency in the risk-regulation process (including public participation in the wider debate about risk and risk management) may offset these effects should such an event occur.

ACKNOWLEDGEMENTS

The research reported here was funded by the Biotechnology and Biological Sciences Research Council in the UK.

REFERENCES

1. Stenholm, C. W. & Waggoner, D. B., Public policy. In *Animal Biotechnology in the 1990s: Opportunities and Challenges*, ed. J. Fessenden-MacDonald. National Agricultural Biotechnology Council, Ithaca, NY, 1992, pp. 25–35.
2. Bauer, M. (ed.), *Resistance to New Technology*. Cambridge University Press, Cambridge, 1995.
3. Van den Daele, W., Background to the perception of risks in genetic engineering: concepts of nature and the semantics of risk. In *Risk is a Construct. Perceptions of Risk Perception*, ed. B. Ruck. Knesebeck, Munich, 1993, pp. 157–79.
4. Joss, S. & Durant, J., *Public Participation in Science: The Role of Consensus Conferences in Europe*, Science Museum, London, 1995.
5. Slovic, P., Perceived risk, trust and democracy. *Risk Analysis*, **13** (1993) 675–82.
6. Bauer, M., Resistance to new technology and its effects on nuclear power, information technology and biotechnology. In *Resistance to New Technology*, ed. M. Bauer. Cambridge University Press, Cambridge, 1995, pp. 1–45.
7. Frewer, L. J., Howard, C. & Shepherd, R., The influence of realistic product exposure on attitudes towards genetic engineering of foodstuffs. *Food Quality and Preference*, **7** (1996) 61–7.
8. Frewer, L. J., Howard, C. & Shepherd, R., Public concerns in the United Kingdom about general and specific applications of genetic engineering: Risk, benefit and ethics. *Science, Technology and Human Values*, **22** (1997) 98–124.
9. Hamstra, A., Consumer research on biotechnology. In *Biotechnology In Public. A Review Of Recent Research.*, ed. J. Durant. Science Museum, London, 1992, pp. 42–51.
10. Heijs, W. J. M., Midden, C. J. H. & Drabbe, R. A. J., *Biotechnolgy: Attitudes and Influencing Factors.* Eindhoven University of Technology, Eindhoven, 1993.
11. Dijksterhuis, G. B. & Gower, J. C., The interpretation of generalised Procrustes analysis and allied methods. *Food Quality and Preference*, **3** (1991) 67–87.

12. Saba, A., Moles, A. & Frewer, L. J., Public concerns about general and specific applications of genetic engineering: A comparative study between the UK and Italy. *J. Nutrit. Food Sci.* **28** (1998) 19–30.
13. Straughan, R. & Reiss, M., *Improving Nature? The Science and Ethics of Genetic Engineering*. Cambridge University Press, Cambridge, 1996.
14. Hedderley, D. I. & Wakeling, I. N., A comparison of imputation techniques for internal preference mapping using Monte Carlo simulation. *Food Quality and Preference*, **6** (1995) 281–97.
15. Frewer, L. J., Hedderley, D., Howard, C. & Shepherd, R., 'Objection' mapping in determining group and individual concerns regarding genetic engineering. *Agriculture and Human Values*, **14** (1997) 67–79.
16. Frewer, L. J., Howard, C. & Shepherd, R., Understanding of risk perceptions associated with different food-processing technologies—a case study using conjoint analysis. *Food Quality and Preference*, **8** (1997) 271–80.
17. Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S. & Combs, B., How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences*, **9** (1978) 127–52.
18. Ruck, B. (ed.), *Risk is a Construct, Perceptions of Risk Perception*. Knesebeck, Munich, 1993.
19. Frewer, L. J., Howard, C. Hedderley, D. & Shepherd, R., What determines trust in information about food-related risks? Underlying psychological constructs. *Risk Analysis*, **16** (1996) 473–86.
20. Rabino, I., German genetic engineering scientists and the German public: Complementary perceptions in a changing European context. *Public Understanding of Science*, **3** (1994) 365–402.
21. Evans, G. & Durant, J., The relationship between knowledge and attitudes in public understanding of science in Britain. *Public Understanding of Science*, **4** (1995) 57–74.
22. Campion, E., Frewer, L. & Miles, S., Public understanding of food science. *Proceedings, 5th European Congress of Psychology*, Dublin, 6–11 July 1997.
23. Ajzen, I., *Attitudes, Personality and Behaviour*. Open University Press, Milton Keynes, UK, 1988.
24. Sparks, P., Shepherd, R. & Frewer, L. J., Assessing and structuring attitudes towards the use of gene technology in food production: The role of perceived ethical obligation. *J. Basic Appl. Social Psychol.* **16** (1995) 267–85.